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HYDROLOGY and BOTANY.—*Plants as indicators of ground water.*[1]

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PHREATOPHYTES

Perhaps the most outstanding feature of the flora of the desert is its relation or lack of relation to the water table. On the one hand are the true xerophytes, which have adaptations for extreme economy of water, depend on the rains that occur at long intervals for their scanty supplies of water, and during prolonged periods of drought maintain themselves in a nearly dormant condition. On the other hand are the plants that habitually grow where they can send their roots down to the water table or to the capillary fringe immediately overlying the water table and are thus able to obtain a perennial and secure supply of water.

The term phreatophyte is used by the writer to designate a plant that habitually obtains its water supply from the zone of saturation, either directly or through the capillary fringe.[2] The term is obtained from two Greek roots and means a "well-plant." Such a plant is literally a natural well with pumping equipment, lifting water from the zone of saturation. The term ground water is used in this paper to designate the water in the zone of saturation—that is, below the water table.

[1] Published by permission of the Director of the U. S. Geological Survey. Received Oct. 29, 1926.

[2] MEINZER, O. E., *Outline of ground-water hydrology, with definitions*, U. S. Geol. Survey Water-Supply Paper 494: 55. 1923. In so far as the writer is informed, the term phreatophyte was first used by him in a mimeographed edition of the paper which was later issued, in revised form, as Water-Supply Paper 494.

The phreatophytes form a fairly definite and well recognized ecologic group in the desert regions but a much less definite group in the humid regions where water supplies from other sources are more abundant. In the most arid deserts they stand in sharp contrast to the true xerophytes, which do not utilize water from the zone of saturation. As one passes, however, into less arid and then into more and more humid regions the control of the water table becomes progressively less rigid, until its discipline, as it were, becomes quite demoralized, and even its most subservient vassals wander away and live at will in all sorts of situations where they are entirely beyond its control.

Even in the desert regions many if not all phreatophytic species will spread more or less to localities where they are not in reach of the water table, such as irrigation ditches, irrigated fields, streams and dry washes that are far above the water table, or even alluvial slopes and hillsides. It is also true that plants of species which do not habitually utilize ground water may do so under certain circumstances and may flourish, at least for a time, on such a water supply. Moreover, there is not always a wholly definite distinction between ground water and other soil moisture because of the existence of a great variety of perched and temporary water tables and of gravity water that may be in transit from the surface to the water table. However, these exceptions and complicating conditions do not alter the important fact that there are certain plant species which habitually feed on ground water and others which do not, and that in the arid regions there is a very real and conspicuous distinction between these two groups.

HISTORY OF THE SUBJECT

As might be surmised, the subject of plants as indicators of ground water is by no means a new one. Vitruvius, who lived about the time of Christ and who is credited as being the first writer to advocate the modern theory of the origin of ground water, called attention to the value of certain plants in locating water supplies. Statements on the same subject are found in the writings of Pliny, in the first century A. D., who virtually quoted Vitruvius, and in those of Cassiodorus, in the sixth century, who obtained his ideas largely from a professional water finder that came to Rome from the arid regions of Africa.

The subject has, however, received little attention in modern times in the European countries in which the science of ground-water hydrology has been developed. Most of the French and German

treatises on ground water either do not mention it at all or else dispose of it very briefly. The reason for this is doubtless that the hydrologic work in these countries was done chiefly where relatively humid conditions prevail and where, therefore, the subject of plants as indicators of ground water does not have much significance. It may be noted that Cassiodorus became interested in the subject through an "aquilege" who came to the court of Theodoric from Africa. "Because of the great aridity of the terranes of his country," wrote Cassiodorus, "the art of discovering springs is there cultivated with the greatest care." The most definite and thorough study of the subject seems to have been made by a Frenchman named Amy,[3] who published a comprehensive paper on his observations in 1861. The proposition that plants of certain species more than others utilize water from the zone of saturation has been recognized by various eminent botanists, such as Warming, who based his statements largely on the work of Fielberg, Raunkiär, and Massart.

In the desert region of the United States, which covers about half a million square miles, the relation of the native vegetation to ground water is a subject of great scientific and practical importance, yet even in this region it has received but little systematic study. Coville,[4] in a report on a botanical reconnaissance in the Mohave Desert and Death Valley in 1891, described the zonal arrangement of the vegetation surrounding playas and divided the plants found in the desert into two significant classes—those of humid habitat and those of arid habitat. His list of plants of humid habitat probably comes nearer to being a catalogue of desert phreatophytes than anything else that has been published in this country. The botanists of the Desert Botanical Laboratory, which was established in 1903, have generally recognized the relation of certain species to the water table, and the subject has been given especial attention by Spalding[5] and Cannon.[6] In a valuable investigation made by the Department of Agriculture

[3] AMY, F., *Voyages d'un hydroscope, ou l'art de decouvrir les sources.* Paris. 1861.

[4] COVILLE, F. V., *Botany of the Death Valley expedition.* Contrib. U. S. Nat. Herb. 4: 23, 31, 32, 35, 38, 39, 47. 1893.

[5] SPALDING, V. M., *Distribution and movements of desert plants,* Carnegie Institution of Washington Pub. 113: 5–17. 1909.

[6] CANNON, W. A. *The root habits of desert plants,* Carnegie Inst. Washington Pub. 131. 1911. *Some relations between root characters, ground water, and species distribution,* Science new ser. 37: 420–423. 1923. *Tree distribution in central California,* Popular Science Monthly pp. 417–424, 1914.

of the indicator significance of native plants in Tooele Valley, Utah,[7] the relation of the principal phreatophytes, such as greasewood, to the water table was recognized, and some precise information was obtained bearing on the subject of plants as indicators of ground water. Valuable work has more recently been done by Shantz, Aldous, Piemeisel, and others on the general subject of the indicator significance of native plants in the arid and semiarid regions of the United States, including some reference to ground water. Much of this recent work has been done in connection with the classification of the public domain by the Geological Survey with respect to its irrigability and its value for grazing. In the older water-supply papers of the Geological Survey dealing with ground water no mention is generally made of discharge by plants or indeed by evaporation from the soil. In recent years, however, in the investigations in the desert regions the great importance of these processes has been fully recognized and attention has necessarily been given to the plants that feed on ground water. The numerous water-supply papers that have resulted from these investigations contain considerable specific information on the subject, especially those of J. S. Brown, Kirk Bryan, Everett Carpenter W. O. Clark, C. H. Lee, C. W. Riddell, C. P. Ross, A. T. Schwennesen, D. G. Thompson, and G. A. Waring. Decisive data on certain species have been obtained through the use of water-stage recorders over wells by G. E. P. Smith, irrigation engineer in the University of Arizona, and by W. N. White, of the United States Geological Survey. The present paper is based chiefly on observations made by the writer during 19 years of hydrologic work in the desert region, but also in large part on the data published in papers by the investigators that have been mentioned.

EVIDENCES OF PHREATOPHYTIC HABIT[8]

The evidences that plants of certain species possess the phreatophytic habit or adaptation whereas those of other species do not may be grouped as follows: (1) Observations of the root habit of different species showing their relation or absence of relation to the water table

[7] KEARNEY, T. H., BRIGGS, L. J., SHANTZ, H. L., MCLANE, J. W., and PIEMEISEL, R. L., *Indicator significance of vegetation in Tooele Valley, Utah.* U. S. Dept. Agri. Journ. Agric. Research 1: 365–417. 1914.

[8] Detailed data on the subject are given in a comprehensive paper by the writer which has been approved by the Director of the United States Geological Survey for publication as a water-supply paper.

and showing the ability of some species to send roots to great depths; (2) experiments with certain species in which the quantities of water they absorb from the zone of saturation are measured or the effects of their growth in lowering the water table are recorded; (3) determinations of soil moisture during dry periods in an arid region, showing that certain species grow chiefly or exclusively in soil which contains moisture that could not have been supplied by rains but must have risen from the zone of saturation, whereas other species are found chiefly or exclusively with their roots in soil that is not moistened by ground water; (4) observations in arid regions of the relation or absence of relation of the period of growth of different species to the rainy season, showing that certain species (commonly growing where the ground water is beyond the reach of the plant roots) become dormant after the supply of soil moisture derived from the rains has been exhausted, whereas other species (growing where the ground water is within reach) continue to grow actively throughout the summer; and (5) observations in arid regions of the depth to the water table, showing that certain species are confined almost completely to areas with specific depth limits, whereas others show no relation to the water table and may grow where the water table is at a great depth or is entirely absent. The zone of shallow ground water surrounding a desert playa can generally be subdivided into several concentric belts of vegetation, in each of which one or more phreatophyte species is dominant. The successive belts vary in texture and alkalinity of soil as well as in depth to the water table. However, the main factor in the control of the vegetation over the area of shallow ground water is the depth to the water table. This fact is proved by the existence of otherwise similar basins which, on account of subterranean leakage, do not have shallow ground water in their interior lowlands. In these basins there may be a barren central playa with clayey, alkaline soil, surrounded by belts of soil having essentially the same texture as that of the soil in the basins that have shallow ground water, yet the familiar phreatophytes are essentially absent and the ordinary desert species extend to the margins of the playas. Doubtless there are some differences in the amount and distribution of the alkali in the soil resulting from the absence of shallow ground water, but in view of the characteristic growth of phreatophytes in many well-drained areas of shallow ground water it is certain that the absence of these species in the basins having deep ground water is not due to a difference in soil alkali.

RELATION OF PHREATOPHYTES TO OTHER ECOLOGIC GROUPS

Relation to hydrophytes.—Water-loving plants might be divided into (1) those which grow entirely under water, (2) those which have only their roots under water, (3) those which have their roots in saturated soil, and (4) those which grow where there is a zone of aerated soil between the land surface and the water table but where the zone of saturation or the overlying capillary fringe is within reach of their roots. The phreatophytes consist of the last two of these groups. If the term hydrophyte were used in a very inclusive sense to comprise all four groups then the phreatophytes would, of course, become a subdivision of the hydrophytes.

However, the distinction as to whether the body of water that feeds the plant is surface water or ground water is perhaps less important than the relation of the roots to the body of water—a question on which there is still great lack of information. Many phreatophytes probably develop a root system in the capillary fringe and avoid, so far as possible, sending their roots into the zone of saturation, thus differing in an important respect from true hydrophytes, whose roots are normally under water. However, the phreatophytes which are closely allied to the hydrophytes and which grow where the water table is very near the surface doubtless have functional roots in the zone of saturation. Moreover, G. E. P. Smith found both cottonwood and mesquite roots highly developed below the water table. The water table everywhere fluctuates. In most places within the areas occupied by phreatophytes the seasonal fluctuation amounts to as much as 2 or 3 feet and in some places it amounts to more than 25 feet. This fluctuation is probably beneficial because on the whole it produces a thicker belt of aerated soil that is moistened by ground water. It, however, raises interesting and important questions as to how the root system is adjusted to the fluctuations of the water table.

Relations to halophytes.—The halophytes in the arid regions virtually form a subdivision of the phreatophytes because the alkaline soils in which they grow are nearly confined to the areas that have ground-water discharge. Nevertheless many of these halophytes resemble the xerophytes in having to subsist on small quantities of water. It is well known that a plant in order to absorb soil water must have a tissue fluid of higher osmotic pressure and, therefore, of higher salt content than the soil water. For this reason the highly concentrated soil water is relatively unavailable to the plants, and the soil that

contains such highly concentrated water is said to be physiologically dry even if it is saturated. Because of the slow rate at which these halophytes absorb water they require adaptations for controlling transpiration similar to those of xerophytic plants. The high concentration of the tissue fluid itself retards transpiration.

The soils and subsoils underlying many of the playas and adjacent belts of succulent halophytes are, moreover, very clayey and tight, and therefore have only small supplies of available water in spite of the high water table and abundant water supply of the surrounding belt of more permeable soil. Thus the supply available to plants may be meager because of the fine texture and impermeability of the soil and subsoil as well as the high concentration of the soil water. It is known, however, that in the more permeable belts surrounding the clay cores a very alkaline soil may be underlain by ground water that is not excessively mineralized and that may indeed be very pure. Grasses that flourish on alkaline soil, such as salt grass and alkali saccaton apparently have considerable transpiration. This fact leads to the suggestion that they may obtain most of their water supply not from the physiologically dry soil but from the relatively pure water of the zone of saturation. Deep rooting plants that are found in alkaline soils may also be relatively independent of the alkali in the top soil and may feed on the relatively pure ground water.

Relation to xerophytes.—The desert phreatophytes have a humid environment for their roots but they resemble the xerophytes in having a dry environment for their transpiratory organs. Moreover, some phreatophytes, chiefly those which send their roots to great depths to reach the water table, have considerable ability to endure adverse soil-moisture conditions when they are not in contact with an adequate ground-water supply. The young plants of these species, if they have grown from seeds, must be able to withstand drought until their roots reach the ground water; moreover, if they find ground water only at great depth the rate at which they can lift the water to their stems and leaves may be too low to allow rapid transpiration. However, the reward of a perennial water supply comes to the individual plants that are not only thrifty in their use of soil moisture, but are also effective in sending down their roots. The individuals that reach the water table are likely to survive and to reproduce their kind in preference to those that were less successful in developing deep roots. Moreover, among the individuals that reach the water table the victory will, as a rule, be to those which are the most capable in utilizing

ground water. Hence, natural selection should produce a species which has xerophytic adaptations but which nevertheless is an efficient phreatophyte with a capacity to send strong roots to great depths rapidly and to pump ground water effectively up through these roots.

Relations to mesophytes.—A number of species, chiefly forest trees such as birch and sycamore, are widely distributed through the humid regions and also grow in arid regions where ground water is within reach. They are generally regarded as mesophytes rather than hydrophytes. They are mesophytes in the sense that they can not tolerate much alkali and apparently have no special adaptations for resisting drought. In the arid regions they are found in the mountain canyons and large arroyos that have an underflow and in other places that have shallow ground water but fairly good drainage. They are commonly not associated with salt grass and greasewood, on the alkaline soils, nor with mesquite in areas of good soil where the water table is at considerable depth. Even casual observations of the forests in humid regions will show that the trees of this type have an affinity for the water table in humid as well as in arid regions. If it were not for their ability to utilize water from the zone of saturation and the poor development of this adaptation in other trees it could reasonably be expected that the other trees would be the most successful and the water-loving trees the least successful in establishing themselves in the arid regions.

VALUE OF PHREATOPHYTES AS INDICATORS OF GROUND-WATER CONDITIONS

Occurrence of ground water.—The phreatophytes are of great practical value as indicators of the occurrence of ground water in arid regions. They give evidence which supplements that furnished by the topography and geology and is more specific as to the precise localities where the water occurs near the surface. They can not properly be ignored or relegated to casual consideration in any ground-water survey of a desert region. Many inhabitants of desert regions have a keen appreciation of the value of plants as indicators of ground water and an almost intuitive sense of the significance of particular native species. Doubtless some of this practical knowledge was possessed by primitive men long before the dawn of human history, and indeed as long ago as man first essayed to dwell in the desert regions or to cross the vast expanses of these dread regions.

These plants are also of great value to travelers in the desert in directing them to existing watering places. In an uninhabited region in which the distance between watering places may be 10, 20, or 50 miles, it is sometimes difficult for a stranger to locate the precise spot where the water occurs, even with such clues as are furnished by roads and animal trails. Clumps of cottonwoods or of tall stately palm trees may be visible from a great distance, and much help and comfort may also be afforded by so humble a phreatophyte as salt grass, either by being visible as a green patch at a distance, or at closer range by giving the traveler definite assurance of the proximity of ground water and virtual assurance that the watering place is not far away.

Depth to the water table.—The clues as to depth to ground water that can be obtained from the different plant species are of considerable practical value, and for persons in distress they may be a matter of life or death. Thus a person without tools and in a weakened condition might be unable to dig down to the water that supplies a mesquite bush although he would have a good chance of finding water where salt grass and palm trees are growing. In estimating for a given area the acreage of irrigable land within certain feasible limits of lift, invaluable use can be made of the clues furnished by the successive belts of native vegetation. The limits of depth for all species are somewhat indefinite and are affected by the texture of the soil. With a few exceptions the greatest depth below the surface from which ground water is known to be lifted by plants is about 50 feet.

GENERAL LIMITS OF DEPTH TO WATER TABLE INDICATED BY PRINCIPAL PHREATOPHYTES IN AREAS INVESTIGATED

Rushes and sedges—Water at surface or water table within a few feet.

Giant reed grass (*Phragmites communis*).—Water at surface or water table within a few feet—probably not more than 8 feet. Giant wild rye (*Elymus condensatus*). Water very near surface to a depth of 12 feet or more. In subhumid regions wild rye may grow without relation to water table.

Salt grass (*Distichlis spicata*).—Water very near surface to a maximum depth of 8 to 12 feet or rarely more.

Mexican salt grass (*Eragrostis obtusiflora*).—Water very near surface to depth of about 15 feet.

Pickleweed (*Allenrolfea occidentalis*).—Water generally within a few feet but sometimes at a depth of 20 feet and more.

Arrow weed (*Pluchea sericea*).—Water at surface or water table at depths ranging to 10 feet or more—probably as much as 25 feet.

Palm trees (*Washingtonia filifera*).—Water table within a few feet.

Willow.—Water at surface or water table 12 feet or more below surface (?).

Alkali saccaton (*Sporobolus airoides*).—Water less than 5 feet to depth of 25 feet and in some places much more. Most luxuriant growth where depth is between 5 and 15 feet. Alkali saccaton that occurs where depth is much more than 25 feet probably does not send roots to ground water.

Rabbit brush (*Chrysothamnus graveolens*).—Water about 2 to 15 feet below surface, 8 feet or more for most luxuriant growth. Also grows extensively as a non-phreatophyte.

Big greasewood (*Sarcobatus vermiculatus*).—Water 3 feet or less probably to depth of 40 feet or more. Abundant and luxuriant growth between 10 feet (or less) and 20 feet. Greasewood that occurs where depth is more than 50 feet probably does not send roots to ground water.

Mesquite.—Water less than 10 feet to 50 feet or more below surface. Mesquite that grows where depth is much more than 50 feet probably does not send roots to ground water.

Quality of ground water.—That certain plants indicate the quality as well as the occurrence of ground water is widely believed by people in arid regions, and there is doubtless some basis for this belief. In general the rushes, sedges, and reeds indicate fairly good water, but there are probably many exceptions to this rule. The succulent alkali-resistant plants, such as pickleweed and samphire, are likely to indicate highly mineralized water immediately under the water table, but the water a little deeper down may be much better. Where salt grass or alkali saccaton is growing the water may be good or it may be very bad. Palm trees and greasewood also indicate water of doubtful quality, but potable water can generally be obtained in the vicinity of vigorous palms. Mesquite generally though not invariably indicates good water. The meso-phreatophytes, such as birch and sycamore, commonly indicate good water.

The data obtained by the writer show that the species which he investigated, with the possible exception of pickleweed (*Allenrolfea occidentalis*), may grow where the upper layer of ground water contains only small amounts of mineral matter and is of good quality. Thus, of 13 samples of ground water obtained in Big Smoky and Ralston

Valleys, Nevada, at points where salt grass was growing, 11 samples contained less than 1,000 parts per million of total solids, 8 contained less than 500 parts, and 5 contained less than 300 parts, the minimum being only 137 parts. Of these 13 samples more than half contained less than 35 parts per million of chloride, the minimum being only 4 parts. Greasewood and rabbit brush, in Big Smoky Valley, and alkali saccaton and mesquite in Sulphur Spring Valley, Arizona, have equally good records.

On the other hand, the data show that all these species may be found growing where the ground water is highly mineralized, even mesquite not being an exception. This is not surprising when one considers the usual high concentration of soil moisture in comparison to that of ground water. Even though the plants may to some extent avoid the soil alkali by getting their roots close to the water table they can not wholly avoid it, especially at times when a part of the alkali is washed down to the water table. For this reason it is perhaps futile to expect that any definite relations can be found between the occurrence of phreatophytes and the quality of the ground water or that any species that can grow in even moderately alkaline soil will invariably indicate potable water.

Quantity of ground water.—In many of the arid valleys of the West projects for pumping large quantities of water from wells for irrigation or public supplies have been carried out or are under consideration. For these projects it is necessary to know as nearly as possible how much ground water can be recovered year after year without seriously depleting the supply stored in the underground reservoirs. As a rule the pumpage should not exceed the natural discharge but should merely salvage the ground water that would otherwise be disposed of by natural processes. In these valleys the ground water is naturally discharged largely by transpiration. To estimate the quantity annually discharged from a given valley it is necessary to determine both the areas occupied by these plants and the rate at which they give off water by transpiration.

The areas occupied in a given valley by the different associations of phreatophytes can readily be determined by a survey of the valley. The information thus obtained, even without any definite information as to the rate of transpiration, is of great practical value in estimating the probable safe yield of the valley and in determining the magnitude of pumping projects to be undertaken. For example, in Steptoe Valley, Nevada, in which exploratory drilling was done several years ago by

the Geological Survey,[9] it was found that ground water is being discharged, through evaporation from soil and the growth of native plants such as salt grass, rabbit brush, and greasewood, over an area of about 115,000 acres. The discharge per acre is probably much less than the quantity of water required per acre to irrigate useful crops, such as alfalfa, grain, or vegetables, and, moreover, not all of this water can be salvaged by pumping from wells. Nevertheless, the great extent of the area of discharge and the luxuriant character of its vegetation give reliable evidence that a substantial supply of ground water is available.

The rate at which ground water is discharged by plants may reasonably be expected to vary with the plant species, the depth to the water table, the texture and alkali content of the soil, and the weather conditions. Each of these factors is somewhat complex, especially the last two. Various ingenious methods have been devised for determining the rate of ground-water discharge by transpiration, and some of these methods are now in use by the Geological Survey.

DEVELOPMENT OF PHREATOPHYTES OF ECONOMIC VALUE

The extensive investigations of the Geological Survey have shown that very large supplies of ground water occur in practically all the western States. In California about a million acres are irrigated with ground water pumped from wells, but in the other arid States comparatively little irrigation has hitherto been accomplished with water from wells because of the prohibitive cost of pumping, and, therefore, most of the annual supply of ground water goes to waste or supports plants of very low value. The investigations in Big Smoky and Steptoe Valleys, Nevada, indicate that not far from 10 per cent of the drainage basins of these valleys contain plants that live on ground water. If these basins have anywhere near average conditions it follows that there are a few million acres of phreatophytes in Nevada alone. A part of this land is alkaline but much of it has good soil. Pumping water for irrigation is expensive even where the lift is not great. The plants, however, lift the water without cost, and if phreatophytes of economic value can be developed the means will be at hand for utilizing vast quantities of water that now virtually go to waste and making hundreds of thousands of acres of desert land productive. The best results in this type of agriculture have thus far been obtained with alfalfa, chiefly for producing seed. Bermuda grass and pecan trees are also examples of promising phreatophytes of economic value.

[9] CLARK, W. O., and RIDDELL, C. W., *Exploratory drilling for water and use of ground water for irrigation in Steptoe Valley, Nev.* U. S. Geol. Survey Water-Supply Paper 467: 13. 1920.

BOTANY.—*New plants mainly from western South America.*[1] ELLSWORTH P. KILLIP, U. S. National Museum.

The representation of plants from western South America in the United States National Museum has increased substantially in recent years as a result of extensive collecting by local South American botanists and by members of scientific expeditions from the United States to South America. In the course of studying this material several new species have been discovered, descriptions of which are here published in order that the names may be available in the preparation of reports upon these collections. A single species from eastern Argentina is included.

Anthurium antrophyoides Killip, sp. nov.

Plant terrestrial; caudex 4 to 6 cm. long, 1 to 2 cm. thick; petioles 14 to 18 cm. long, canaliculate above, geniculate at base; leaves rhombic-ovate-lanceolate, 17 to 18 cm. long, 9 to 10 cm. wide, with a triangular long-acuminate apex, abruptly cuneate-narrowed to petiole, suboblique, coriaceous, bright green, minutely and densely whitish-punctate above, glabrous, the nerves and veins prominent, the basal nerves 4 to a side, the outermost nerve reaching to within 0.3 mm. of the margin in the lower half, extending to base of acuminate apex and anastomosing with second basal nerve, the second nerve reaching to about 1.5 mm. from the margin just above middle, and extending to apex, the 2 inner basal nerves and the lateral nerves (about 8 to a side) anastomosing with the second nerve above middle, peduncle about 12 cm. long; spathe oval, 5 cm. long, 3 cm. wide, rounded at apex and abruptly caudate-acuminate (acumen 1 cm. long), white; stipe 1 cm. long; spadix 3 cm. long, 0.5 cm. thick; perianth segments equal, about 0.8 mm. long, 1 mm. wide.

Type in the U. S. National Herbarium, no. 1,143,244, collected along Río Caballete, near junction with Río Dagua at Santa Rosa, Department El Valle, Colombia, altitude 200 meters, September 22, 1922, by E. P. Killip (no. 11555).

According to Engler's revision of *Anthurium* in Das Pflanzenreich this species apparently comes nearest *A. weberbaueri*, the venation and general shape of the leaves being quite similar. The leaves of *A. antrophyoides*, however, are acute at base, not obtuse; the spathe is proportionately much broader; the peduncles are shorter than the leaves, while in *A. weberbaueri* they exceed the leaves, and the flowers are smaller. Comparison of the type specimen with type material of *A. weberbaueri* at Berlin has been made by the writer.

The leaves of *A. antrophyoides* bear a very close resemblance to the fronds of the tropical African fern *Antrophyum mannianum*.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 11, 1926.

Anthericum herrerae Killip, sp. nov.

Plant about 30 cm. high, glabrous except at leaf margins; leaves basal, linear, 10 to 20 cm. long, 0.8 to 1 cm. wide, conduplicate, often falcate, acute, 25 to 30-nerved, densely ciliolate, membranous; stem terete, naked or bearing a single bract-like leaf in upper third, the leaf linear-lanceolate, 2 to 4 cm. long, 0.5 to 0.7 cm. wide, subconduplicate; raceme simple or few-branched, bracteate, the lower bracts lanceolate, up to 2.5 cm. long, the upper ovate-deltoid, 0.5 to 1 cm. long; pedicels ascending, about 5 mm. long, articulate just above middle; perianth yellowish-white, the segments narrowly oblanceolate, about 1 cm. long, 0.2 to 0.3 cm. wide, obtuse, 3-nerved; filaments about 5 mm. long; anthers linear, 3 mm. long; ovary oblong, depressed at apex, the ovules 5 or 6 to a cell; style filiform, about 6 mm. long.

Type in the U. S. National Herbarium, no. 1,281,329, collected at Hacienda Churú, Province of Paucartambo, Peru, altitude 3,500 meters, January, 1926, by F. L. Herrera (no. 1012a).

This plant evidently is nearest *A. sprengelii* Rusby (*A. ciliatum* (H. B. K.) Spreng., not *A. ciliatum* L. f.), a species with oblong perianth segments and much longer filaments.

Brodiaea viridior Killip, sp. nov.

Bulb globose, about 1 cm. in diameter; leaves 3 or 4, narrowly linear, 25 to 35 cm. long, 0.5 to 1.2 cm. wide, subcarnose, nearly flat; scape erect, 20 to 30 cm. high, 1 or 2-flowered; spathe bivalved, the valves linear, 1.5 to 2.5 cm. long, connate at base, about 10-nerved, white; pedicels 2 to 3 cm. long, slender, subarticulate at apex; perianth tube cylindric, 8 to 12 mm. long, about 6 mm. wide, the segments oblong-lanceolate, 15 to 20 mm. long, 4 to 4.5 mm. wide, widest at middle, tapering to a subcaudate apex, white, green along the single conspicuous nerve and in upper third; stamens in 2 series, borne at throat of tube, the filaments filiform, 3 to 5 mm. long; style 9 to 10 mm. long; ovary sessile.

Type in the U. S. National Herbarium, no. 704305, collected in the vicinity of General Roca, Río Negro valley, Argentina, altitude 250 to 360 meters, September 28, 1914, by Walter Fischer (no. 122).

In Baker's key[3] to this group of species *B. viridior* would come nearest *Brodiaea* (*Milla*, of Baker) *poeppigiana*, a Chilean plant with lilac flowers having shorter, merely acute segments.

Zephyranthes parvula Killip, sp. nov.

Bulb globose, 1 to 1.5 cm. in diameter, the neck 1 to 2 cm. long; leaves 2 to 4, narrowly linear, 2 to 3 cm. long, 1 to 1.5 mm. wide, acutish; peduncles about 1.5 cm. long; spathe 1.5 to 3 cm. long, closely enveloping the flower tube, bifid in upper quarter; ovary sessile; flower tube narrowly funnel-shaped, about 1 mm. wide at base, 3 mm. wide at throat, 1.5 to 2 cm. long, whitish in lower half, deep pink in upper, the segments oblong, subequal to tube, 5 to 7 mm. wide, rounded at apex but usually with a minute tip, deep pink at center, pale toward margin, purplish-veined; stamens inserted just

[3] Journ. Linn. Soc. 11: 383. 1871.

above middle of tube, the filaments 6 to 8 mm. long, exserted about 4 mm. beyond throat of tube but extending not beyond lower third of segments, the anthers linear, about 2.5 mm. long; styles 2 to 2.5 cm. long, the stigmas capitate; fruit broadly ovoid, 4 to 5 mm. long; seeds about 2 mm. long, black.

Type in the U. S. National Herbarium, no. 1,233,250, collected near city of Cuzco, Peru, altitude 3,500 meters, October, 1925, by F. L. Herrera (no. 822). A specimen collected by Casimir Watkins in 1916 also belong to this species.

In Baker's revision[3] of *Zephyranthes* this species would come nearest *Z. albicans* and *Z. boliviensis*, the only species of the subgenus *Pyrolirion* with light-colored flowers. It is a much smaller plant than either of these, and the stigmas are capitate, not trifid.

The local name is given as *pulla-pulla*.

Boerhaavia verbenacea Killip, sp. nov.

Plant herbaceous, annual, erect, up to 60 cm. high or more; stems terete, somewhat viscous, glabrescent below, puberulous above, the branches stout; leaves lanceolate or narrowly oblong-lanceolate, 1.5 to 3 cm. long, 0.4 to 1 cm. wide, obtuse or acutish at apex, acute at base, subsessile (or the lower with petioles up to 1.5 cm. long), entire or slightly undulate, viscid-puberulent, black-punctate, especially beneath; inflorescence paniculate, the panicle up to 30 cm., dichotomous, the branches glabrous, longitudinally striate with black, the flowers sessile or short (not more than 1 mm.)-pediceled, in racemes 3 to 7 cm. long; bracts ovate-lanceolate, 2 to 4 mm. long, acute, mucronate, pale at margin, persistent; perianth 1.5 to 2 mm. long, puberulent; stamens 2, included; fruit broadly obovoid, 3 mm. long, 2 to 2.5 mm. wide, truncate at apex, 5-angled, the angles with conspicuous crenulate or subentire wings, the sulci rugose.

Type in the U. S. National Herbarium, no. 1,281,334, collected at Talara, Department of Paita, Peru, near sea-level, August 22, 1925, by Oscar Haught (no. 8).

This is apparently the only species of *Boerhaavia* with racemose flowers known from South America. From the seven Mexican species with a similar inflorescence *B. verbenacea* is readily distinguished by the fruit, which is nearly twice as wide and wing-angled.

Escallonia claudii Killip, sp. nov.

Shrub, essentially glabrous throughout; younger branches straight or slightly flexuous, quadrangular, sulcate, smooth, yellowish, densely leafy in upper part; leaves simple, obovate or ovate, 0.5 to 2.5 cm. long, 0.4 to 1.5 cm. wide, rounded or acute at apex, cuneate at base, finely callous-serrulate, penninerved (midnerve prominent beneath, the 5 or 6 pairs of lateral nerves less prominent), coriaceous, light green when dry, finely puberulous above; flowers solitary in the axils of the upper (floral) leaves on branches up to 8 cm. long, forming a simple raceme, the pedicels 1 to 2 mm. long, quadrangular,

[3] Amaryll., p. 30. 1888.

bibracteate; bracts linear, 2 to 3 mm. long, coriaceous; calyx obconic, 2 to 3 mm. long, 1.5 to 2 mm. wide at throat, the lobes deltoid-subulate, about 0.5 mm. long; petals linear-spatulate, 6 to 8 mm. long, about 0.8 mm. wide below, dilated to about 3 mm. toward apex, white or pink (?), erect, the apex divarcate, conspicuously purple-veined; stamens at length recurved, the filaments slightly shorter than the petals, the anthers linear, 2 to 2.5 mm. long; style 6 to 8 mm. long, the stigma capitate; ovary turbinate, sulcate.

Type in the U. S. National Herbarium, no. 1,059,295, collected at Ramón, Chile, November 25, 1920, by Brother Claude Joseph (no. 1281).

In Reiche's Flora of Chile[4] and in Engler's monograph[5] of *Escallonia* this new species would come nearest *E. carmelita* Meyen. That species, however, has elongate calyx lobes which are nearly as long as the tube, shorter anthers, and nearly terete branches.

This is one of several plants of exceptional interest represented in the large Andean collections sent the U. S. National Museum by Brother Claude Joseph.

Weinmannia caucana Killip, sp. nov.

Tree; bark of younger branches dark silvery-gray, the ends of the branches and rachis of the racemes densely ferruginous-hirsute; leaves simple, oblong or ovate-oblong, 3.5 to 7 cm. long, 2 to 3 cm. wide, acute or rounded at apex, tapering at base to a petiole 2 to 8 mm. long, coarsely serrate, penninerved (lateral nerves up to 20 pairs), subcoriaceous, dark green and sparingly hirsutulous above, slightly paler and appressed-hirsute on the midrib beneath, the floral leaves similar and smaller; racemes in pairs, 6 to 10 cm. long, the flowers densely congested in contiguous clusters, the pedicels about 3 mm. long; sepals lanceolate, 1 mm. long or less, acute; petals broadly ovate, about 0.8 mm. long, rounded and emarginate at apex, white; stamens very slender, about 3 mm. long, the anthers minute.

Type in the U. S. National Herbarium, no. 1,143,824, collected at Morelos, Cauca Valley, Department of El Cauca, Colombia, altitude 1,680 to 1,720 meters, July 13, 1922, by F. W. Pennell and E. P. Killip (no. 8306).

Related to *W. ovata* Cav. and *W. balbisiana* H. B. K. It differs from the former in having thinner leaves with different venation, denser inflorescence, and smaller flowers; from the latter, in the longer racemes and much smaller sepals, and in the shape of the leaves.

Weinmannia rollottii Killip, sp. nov.

Shrub or small tree, the young branches ferruginous-strigose; leaves simple, ovate-oblong, 1.5 to 3 cm. long, 1 to 2 cm. wide, rounded at apex, rounded or slightly cordulate at base, short (about 4 mm.)-petioled, serrate-dentate, coriaceous, penninerved (about 8 pairs of lateral nerves), reticulate-veined, glabrous or sparingly hirtellous above, hirtellous, especially on the nerves, beneath, the floral leaves smaller, ovate-spatulate, acute at base, subentire; racemes in pairs, 5 to 8 cm. long, ferruginous-strigose, the flowers in approxi-

[4] **3**: 14–32. 1902.

[5] Linnaea **36**: 532–579. 1870.

mate clusters of 4 to 6, the pedicels about 2 mm. long; sepals lanceolate, 1 to 1.5 mm. long, acute, slightly carinate, minutely pilosulous toward apex; stamens 1 mm. long; capsule lance-ovoid, 3 to 3.5 mm. long, glabrous; styles filiform, 2 to 2.5 mm. long.

Type in the U. S. National Herbarium, no. 1,067,899, collected near Páramo de Guasca, Department of Cundinamarca, Colombia, December 27, 1919, by M. A. Rollott (Brother Ariste Joseph) no. A476.

This species is related to *W. bangii* Rusby, but has thicker, smaller leaves, shorter pedicels, and shorter racemes.

Weinmannia nervosa Killip, sp. nov.

Shrub (?); younger branches hirtellous-tomentose; stipules orbicular, 2 to 2.5 mm. wide; leaves 4 to 6 cm. long, short-petioled (petiole about 5 mm. long), unequally pinnate (lateral leaflets 2 to 4 pairs), the midnerve hirtellous-tomentose; leaflets crenate-serrate with 6 to 10 serrations to a side, reticulate-veined (veins prominent above as a grayish network, inconspicuous beneath), subcoriaceous, above dark green, glabrous except for the minutely hirtellous midnerves, beneath light brown (when dry) and glabrous; terminal leaflet obovate or elliptic-ovate, 1.5 to 2.5 cm. long, 1 to 1.2 cm. wide, slightly narrowing toward the obtusish apex, cuneate at base; lateral leaflets oblong, 1 to 2 cm. long, 0.7 to 1 cm. wide, rounded at apex, obliquely cuneate at base; intrafoliar leaves semi-obovate, 7 to 8 mm. long, 1.5 to 2 mm. wide; pseudo-racemes in pairs, 6 to 7 cm. long, the rachis short-hirtellous; bracts broadly ovate, barely 0.5 mm. long, obtuse; flowers 3 to 6 in a glomerule, the glomerules verticillate on the raceme; pedicels about 2 mm. long, longer than the flowers, minutely pubescent; sepals ovate, barely 0.5 mm. long, acute, sparsely pubescent or glabrate; petals ovate, 1 mm. long, obtuse; stamens about 1.5 mm. long, styles shorter than the stamens, as long as, or slightly longer than, the ovary; ovary glabrous.

Type in the U. S. National Herbarium, no. 533,715, collected in the Santa Marta Mountains, Colombia, altitude 1,400 meters, April, "1898–1901," by H. H. Smith (no. 1743).

This specimen was distributed as *W. sorbifolia* H. B. K., a species with leaves fully twice as large. In Engler's monograph of *Weinmannia*[6] this species should come between *W. sorbifolia* and *W. lansbergiana*. From *W. glabra* L. f., another closely related species, it differs in the conspicuous venation on the upper surface of the leaflets and the longer pedicels of the flowers. The specimen was compared with the types of *W. sorbifolia* and *W. lansbergiana* at Berlin.

Geranium filipes Killip, sp. nov.

Rhizome vertical, 4 to 5 mm. thick; stems 2 or 3, all from the apex of the rhizome, slender, few-branched, erect or ascending, 10 to 15 cm. high, exceeding the basal leaves, densely subretrorse-strigillose; stipules linear-lanceolate, 5 to 7 mm. long, about 2 mm. wide, acute, ciliate, otherwise glabrous; leaves orbicular-reniform in general outline, 1 to 1.5 cm. long, 1.5 to 2 cm. wide,

[6] Linnaea 36: 592–650. 1870.

5-lobed about to middle (lobes trilobulate at apex, rarely entire, the segments rounded, mucronulate), membranous, appressed-strigillose above, appressed-pilosulous on nerves beneath, the basal and cauline leaves similar, petiolate, the petioles 3.5 to 7 cm. long; peduncles solitary, very slender, 2 to 5 cm. long, retrorse-strigillose, 2-flowered; bracts linear, 3 to 5 mm. long, acuminate, glabrous; pedicels 4 to 6 cm. long, densely pilosulous; sepals lanceolate, 4 to 5 mm. long, 2 to 2.5 mm. wide, obtusish, conspicuously mucronulate, subtri-nerved, appressed-hirsutulous, densely pilosulous on nerves; petals cuneate-obovate, 5 to 8 mm. long, about 3 mm. wide, rounded at apex, deep pink, pale proximally, the nerves whitish; stamens shorter than calyx, the filaments minutely ciliolate; anthers 1 mm. long.

Type in the U. S. National Herbarium, no. 1,281,331, collected at Hacienda, Churú, Province of Paucartambo, Peru, altitude 3,500 meters, January, 1926, by F. L. Herrera (no. 1044).

This species evidently belongs to Section 16, *Rupicola*, of Knuth's monograph of Geraniaceae.[1] The two Peruvian species of this relationship both have much more numerous, ebracteate, white flowers and non-mucronate leaf lobes.

The local name of the plant is given as *chile-chile*.

Hypseocharis bilobata Killip, sp. nov.

Root cylindric, elongate, thickened, about 20 cm. long, 1.5 to 2 cm. thick, dark purplish; petioles 0.5 to 1 cm. long, puberulous; leaves 2 to 6 cm. long, pinnate, the rachis puberulous or glabrous, the leaflets alternate or sub-opposite, sessile or subsessile, glabrous, the lateral oblong-orbicular, 3 to 6 mm. long, 2 to 5 mm. wide, cordulate at base, the terminal ovate-orbicular, 6 to 10 mm. long, 5 to 8 mm. wide, cordulate and oblique at base, all shallowly bilobate at apex, the sinus to 1.5 mm. deep, the lobes erect, obtuse; peduncles 1.5 to 2 cm. long, 1-flowered, slender; sepals oblong, about 4 mm. long, 3 mm. wide, obtuse; corolla ?; ovary broadly ovoid.

Type in the U. S. National Herbarium, no. 1,190,039, collected near Cuzco, Peru, altitude 3,000 to 3,600 meters, by F. L. Herrera.

The shallowly bilobate leaflets distinguish this from the six other known species of the genus. *Hypseocharis tridentata* has a general resemblance to this species, but in that the leaflets are 3-toothed and the root is not strongly thickened.

Saurauja micayensis Killip, sp. nov

Tree, the branchlets stout, smooth, glabrous or very sparingly strigose, black; leaves oblong-obovate, about 30 cm. long, 15 cm. wide, short-acuminate at apex, subrotund at base, serrulate to base (serrulations about 8 mm. apart), petiolate (petioles 4 to 5 cm. long, stout, sparsely strigose), penninerved (lateral nerves 20 to 22 pairs, the nerves and veins conspicuous beneath), coriaceous, bright green, above glabrous, beneath strigose along the sides of the midrib (hairs very stiff, tuberculate-thickened at base), finely appressed-strigillose along sides of lateral nerves, and finely appressed-strigillose on

[1] Pflanzenreich IV. 129: 144. 1912.

veins, otherwise glabrous; inflorescence paniculate, about 24 cm. long, the rachis and branches stout, black, sparingly pulverulent; bracts lanceolate, 2 to 3 mm. long, acute; flowers 1 to 1.5 cm. wide, pinkish-white, many unisexual; sepals obovate, 2.5 to 3 mm. long, 2 to 2.5 mm. wide, rounded at apex, glabrous, minutely ciliolate at margin; petals oblong, 6 to 7 mm. long, 3.5 to 4.5 mm. wide, obtuse; stamens 15 to 20, 3 mm. long, the anthers linear-oblong, nearly 2 mm. long; styles 5, 3 mm., long; ovary glabrous.

Type in the U. S. National Herbarium, no. 1,142,442, collected at La Galera, near the Micay Valley, Department of El Cauca, southwestern Colombia, altitude 1,900 to 2,000 meters, July 1, 1922, by E. P. Killip (no. 7932).

This species belongs to Buscalioni's section *Oligotrichae Scabrae*, and is probably most closely related to *S. pseudoparviflora* Busc., a plant with a less diffuse panicle and without the stiff hairs along the sides of the midrib of the leaves. These hairs are similar to those of *S. prainiana*, a species of wholly different relationship.

The particular region in which this new species was collected is one of great botanical interest. On crossing the summit of the Western Cordillera at a point nearly due west of Popayán and descending toward the Pacific, the flora takes on a markedly different aspect. Most of the genera are the same as met with in other parts of the Republic, but the species are quite different from those of the northern part of the Pacific slope or of the Cauca and Magdalena valleys. Unfortunately my schedule permitted a stay of only a day and a half in this region, though about 350 numbers were collected. It is to be hoped that the area will be more thoroughly explored in the near future. Only a small portion of this collection has been studied, but several new species and at least two new genera have already been detected.

Saurauja tambensis Killip, sp. nov.

Shrub, the tips of the branches setose-strigose, the hairs tuberculate at base; petioles very slender, 2 to 2.5 cm. long; leaves oblong-obovate, 20 to 25 cm. long, 7 to 9 cm. wide, acuminate at apex, cuneate at base, closely and sharply serrulate except at base, penninerved (lateral nerves 18 to 20 pairs), membranous, the midrib densely setose on both sides (hairs 2 to 3 mm. long, very slender, subappressed), the lateral nerves and the veins with fewer, shorter but similar hairs, the upper surface otherwise glabrous, the under surface with a few blotches of white tomentum; inflorescence about 20 cm. long (including the very slender peduncle 10 cm. long), densely white-tomentose and short-setose, few-branched, the branches about 3 cm. long, 3 or 4-flowered; flowers 1 cm. wide, white, some unisexual; sepals obovate-oblong, 4 to 5 mm. long, 4 mm. wide, rounded at apex, tomentose without, at length nearly glabrous, finely ciliolate, glabrous within; petals slightly longer than sepals, glabrous; stamens 15 to 20, 2 to 2.5 mm. long, the anthers oblong, barely 1 mm. long; styles 5, 1.5 mm. long; ovary glabrous.

Type in the U. S. National Herbariun, no. 1,196,269, collected between Portovelo (gold mine near Zaruma) and El Tambo, Province Oro, Ecuador, altitude 600 to 1,000 meters, September 2, 1923, by A. S. Hitchcock (no. 21281).

This species is nearest *S. intermedia* Busc., approaching the variety *granulosa* Busc., which has fewer (14 or 15) lateral leaf-nerves and shorter flowering branches, not clothed with the thick tomentum of *S. tambensis*.

Saurauja rhamnifolia Killip, sp. nov.

Tree or shrub, the tips of the branches slender, finely and sparingly puberulent or glabrescent, with a very few short setae slightly swollen at base; petioles slender, 1.5 to 2 cm. long, glabrous or sparsely setulose; leaves obovate or oblong-obovate, 8 to 12 cm. long, 4 to 6 cm. wide, short-acuminate or acute at apex, cuneate at base, serrate or serrulate except in lower third (teeth mucronulate), penninerved (lateral nerves 14 or 15, arcuate-ascending from midrib to margin), dark green and glabrous or slightly pulvinate above, paler and glabrous beneath except for a few subappressed setae on the midrib and lateral nerves, membranous; inflorescence about 10 cm. long (including peduncle 3 cm. long), glabrous, the flowers few, subsessile on the main rachis or in two's or three's on short (about 1.5 cm.) branches; bracts linear, 4 to 5 mm. long, obtuse; sepals suborbicular, about 5 mm. long, minutely ciliolate; petals oblong, 6 to 7 mm. long, 4 to 5 mm. wide, rounded at apex; stamens about 25, filaments 2 mm. long, the anthers linear, 3 mm. long; ovary glabrous; styles 5, slender, 4 to 5 mm. long, persistent; fruit depressed-globose, 1 cm. in diameter.

Type in the U. S. National Herbarium, no. 1,022,032, collected in the vicinity of Ambato, Ecuador, August 24–26, 1918, by J. N. Rose (no. 22377).

Saurauja rhamnifolia is related to the preceding species, differing in smaller, thicker leaves with the lateral nerves curved from their base, glabrous inflorescence, fewer and larger flowers, and much more numerous stamens, with linear, longer anthers.

Valeriana herrerae Killip, sp. nov.

Plant herbaceous, 20 to 25 cm. high; root tuberous-thickened, about 1 cm. wide, with numerous fibers; stem simple, slender, yellowish, densely pilose at nodes, glabrous or very sparingly pilosulous elsewhere; basal leaves entire, oblanceolate or spatulate, 1 to 1.5 cm. long, 0.6 to 0.8 cm. wide, obtuse, entire or undulate at margin, tapering to a slender petiole about 2.5 cm. long, dilated at base, glabrous or sparingly pilosulous; cauline leaves ovate or ovate-oblong, 0.8 to 1.2 cm. long, 0.4 to 0.5 cm. wide, obtuse at apex, acute at base, undulate-serrate, glabrous, pilosulous at lower part of margin, the petioles 0.8 to 1 cm. long, glabrous or pilosulous; inflorescence terminal and axillary, in densely flowered, trichotomous cymes in a narrow panicle, the terminal panicle about 3 cm. long; bracts linear-oblong, about 6 mm. long, 1.2 mm. wide, decreasing in size toward apex, obtusish; bracteoles linear, about 2 mm. long, 0.3 mm. wide, obtuse; corolla funnel-shaped, about 1 mm. long, 5-lobed, greenish white; anthers slightly exserted; fruit lance-oblong, about 2 mm. long, faintly 1-nerved on one face, nerveless on other, epappose.

Type in the U. S. National Herbarium, no. 1,281,330, collected at Hacienda Churú, Province of Paucartambo, Peru, altitude 3,600 meters, January, 1926, by F. L. Herrera (no. 1016).

This is a much more slender, less fleshy plant than *P. hyalinorhiza* Ruiz & Pav., its nearest relative. The cauline leaves are less deeply toothed; the cymes are more compact, and the flowers are much smaller and green, not purplish.

The local name is *atoc-atoc*.

SCIENTIFIC NOTES AND NEWS

Dr. S. C. BROOKS of the Hygienic Laboratory, U. S. Public Health Service, has resigned to become Professor of Physiology and Biochemistry and Head of the Department at Rutgers University.

Professor A. S. HITCHCOCK, of the Department of Agriculture is spending a month in Cuba studying the grasses of the island in coöperation with the Tropical Plant Research Foundation. He will return before Christmas.

The Pick and Hammer Club met at the Geological Survey on November 13. M. I. GOLDMAN described petrographic and structural features seen on excursions during and after the International Geological Congress at Madrid, and H. G. FERGUSON described the economic features. C. W. COOKE spoke on the stratigraphy of the beds bearing human remains in Florida.

The Petrologists' Club met at the home of H. G. FERGUSON on November 16. N. L. BOWEN gave some *Notes on Scottish igneous rocks*, and H. S. WASHINGTON discussed the *Petrology of St. Paul's Rocks, Atlantic Ocean*. J. W. GREIG, HERBERT INSLEY, and W. T. SCHALLER were elected members of the Steering Committee for 1927.

In recognition of the 80th birthday of Professor W. M. HOLMES, head curator of anthropology, U. S. National Museum, December 1, he was presented with a volume of personal letters from friends and colleagues in the United States and abroad. Professor Holmes came to the Smithsonian Institution as student artist in 1871.

Dr. DAVID FAIRCHILD, Foreign Seed and Plant Introduction, Bureau of Plant Industry, left New York December 9 on the steamship Conte Roosa for Gibraltar. The latter part of December he will leave Gibraltar for the west coast of Africa, where he will continue his collection and study of seeds and plants for the Bureau.

MESSRS. N. H. DARTON AND A. C. SPENCER are on leave of absence from the Geological Survey and are doing private work in Venezuela and Panama, respectively.

MISS ANNA I. JONAS has been appointed assistant geologist on the Geological Survey.

B. C. RENICK has resigned from the Geological Survey and has gone into commercial geological work.

R. C. MOORE, State Geologist of Kansas, is temporarily at the Geological Survey doing research work on petroleum accumulation for the National Research Council. Professor ANDREW C. LAWSON, president of the Geological Society of America, who has just returned from a trip around the world, is also spending a few weeks in Washington.

Obituary

Dr. CHARLES VANCOUVER PIPER, a member of the ACADEMY, died February 11, 1926, in his 59th year. Dr. Piper was born in Victoria, B. C., and educated in the state of Washington and at Harvard. After ten years as professor of botany and zoology at the Washington Agricultural College he came to the Department of Agriculture. At first in the Office of the Agrostologist, he was, from 1905 until his death chief of the Office of Forage Crop Investigations. He was a born naturalist and from his student days an enthusiastic mountain climber and botanist, making extensive collections from the northwestern states and from Alaska. He is the author of several works on the flora of Washington and Idaho, a large number of papers on systematic botany, and of a revision of *Festuca*, one of the larger genera of grasses. Of late years he was chiefly concerned with the introduction of superior forage grasses and with golf-turf problems. Dr. Piper had been in poor health for two years or more but he remained at work until, three days before the end, he had a paralytic stroke at his desk.

Dr. FRANK H. KNOWLTON, a member of the ACADEMY, died at his home in Ballston, Va., on November 22, at the age of sixty-six years. Dr. Knowlton was born in Vermont and educated at Middlebury. He came to the U. S. National Museum in 1884, and his work during the past forty years on Mesozoic and Cenozoic plants for the Geological Survey and the National Museum is well known. From 1907 until his death he was geologist and paleobotanist of the United States Geological Survey.

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